FREON®

SOLVENT FORMULATION DATA

BULLETIN NO. FST-5E

# "FREON" T-WD 602 SOLVENT

PATENT APPLIED FOR

"Freon" T-WD 602 solvent is a water-in-oil emulsion system which is used for cleaning both water and oil soluble soils. It has been successfully used for the cleaning of complex mechanical and electrical assemblies such as business machines, teletypes, coin changers, and other assemblies where the soils are a mixture of oil soluble and water soluble materials. A comparison of physical properties with "Freon" TF solvent and water is given in the following table.

## PHYSICAL PROPERTIES

| | "Freon" TF | "Freon" T-WD 602 | Water |
|---|---|---|---|
| Boiling Point at one atm. | | | |
| °F | 117.6 | 112.0(1) | 212.0 |
| °C | 47.6 | 44.4 | 100.0 |
| Freezing Point | | | |
| °F | −31.0 | 32.0(1) | 32.0 |
| °C | −35.0 | 0 | 0 |
| Liquid Density at 77°F (25°C) | | | |
| lbs/gal | 13.06 | 12.47 | 8.32 |
| lbs/cu ft | 97.69 | 93.27 | 62.24 |
| grams/cc | 1.565 | 1.494 | 0.997 |
| Vapor Pressure at 77°F (25°C) | | | |
| psia | 6.5 | 7.0 | 0.5 |
| Viscosity at 77°F (25°C) | | | |
| centipoise | 0.682 | 0.94 | 0.89 |
| Surface Tension at 75°F (24°C) | | | |
| dynes/cm | 19.0 | 19.5 | 72.0 |
| Flammability | None | None | None |
| Color | Clear, colorless | Clear, pale yellow | Clear, colorless |
| Toxicity (TLV) ppm | 1000 | (2) | — |
| $K_B$ Value | 31 | 21 | 7 |

(1) Freezing or boiling leads to separation of a top water layer which can be redispersed by stirring after it returns to room temperature.
(2) Vapors under normal use will be comprised almost entirely of "Freon" TF.

## SOLVENT POWER

"Freon" T-WD 602 is used to clean both water and oil soluble soils. Basically most of the materials soluble in "Freon" TF solvent are soluble in "Freon" T-WD 602. Some materials may be soluble in the oil phase and others may be soluble in the water phase. Separation of phases in "Freon" T-WD 602 can be caused by some materials. The following table gives limits of solubility before phase separation occurs.

## SOLUBILITY LIMITS

| | Solubility (Weight %) | |
|---|---|---|
| | "Freon" T-WD 602* | "Freon" TF |
| Acetone | 1.0 | Miscible |
| Benzene | 1.2 | Miscible |
| Chloroform | 2.0 | Miscible |
| Cottonseed Oil | 9.7 | Miscible |
| Ethyl Acetate | 9.8 | Miscible |
| Ethyl Alcohol | 10.4 | Miscible |
| Ethylene Glycol | 1.5 | 0 to 1.4 |
| Glycerin | 1.7 | <0.1 |
| n-Hexane | —Completely Miscible— | |
| Isopropanol | 0.3 | Miscible |
| Methyl Alcohol | 1.1 | Miscible |
| Mineral Oil | 23.2 | Miscible |
| Paraffin Wax, mp 123–127°F | 5.0 | 6.6 |
| Phenol | <0.05 | 1.8 |
| Propylene Glycol | 2.0 | 0 to 1.3 |
| Silicone Oil (1000 centistokes) | 1.3 | Miscible |

*Amount which can be added before a layer separation occurs.

## COMPATIBILITY

"Freon" T-WD 602 exhibits the typical inertness of fluorocarbons to most materials of construction. The only exceptions are those materials which are water sensitive. The tables on page 2 should be used as guides for developing cleaning systems. Testing parts under use conditions is recommended to assure compatibility.

### Plastics

Most plastic materials may be safely cleaned in "Freon" T-WD 602 without damage. Ethyl cellulose, polyvinyl alcohol, and polystyrene probably are not suitable for prolonged contact with "Freon" T-WD 602 solvent. A summary of the effect of "Freon" T-WD 602 on various plastics is given in the following table.

## EFFECT OF "FREON" T-WD 602 AND "FREON" TF ON PLASTICS FOR 75°F. EXPOSURES NORMALLY REQUIRED IN CLEANING

| | "Freon" T-WD 602 (Test Conditions) | | "Freon" TF (Test Conditions) |
|---|---|---|---|
| | 5 min. | 4 hrs. | 5 min. |
| "Alathon" 7050 linear polyethylene resin | 0 | 0 | 0 |
| "Alathon" 9140 polypropylene resin | 0 | 0 | 0 |
| "Delrin" acetal resin | 0 | 0 | 0 |
| Epoxy resin | 0 | 0 | 0 |
| Ethyl cellulose | 0 | 4 | 1 |
| "Kralastic" ABS polymer | 0 | 0 | 0 |
| "Lexan" polycarbonate resin | 0 | 0 | 0 |
| "Lucite" methyl-methacrylate resin | 0 | 0 | 0 |
| Polyvinyl alcohol | 0 | 4 | 0 |
| Polyvinyl chloride (unplasticized) | 0 | 0 | 0 |
| "Styron 475" polystyrene | 0 | 2 | 0 |
| "Surlyn" A ionomeric resin | 0 | 0 | 0 |
| "Teflon" TFE resin | 0 | 0 | 0 |
| "Zytel" 101 nylon resin | 0 | 0 | 0 |

Effect Key:
0 = No visible effect
1 = Very slight effect
2 = Compatibility should be tested
3 = Probably not suitable
4 = Plastic disintegrated or dissolved

### Elastomers

Most elastomers other than silicones can be safely cleaned in "Freon" T-WD 602 solvent. The most suitable elastomers for prolonged service with "Freon" T-WD 602 are "Viton" A, "Adiprene" L, "Thiokol" FA, and "Hypalon" 40.

## EFFECT OF "FREON" T-WD 602 ON ELASTOMERS

Per cent temporary linear swell after immersion for five minutes. Elastomers* tend to return to their original size after drying.

| | Linear Swell, % | |
|---|---|---|
| | Room Temperature | Boiling Point (112°F) |
| "Adiprene" C urethane rubber | 0.6 | 2.2 |
| "Adiprene" L urethane rubber | 0.2 | 1.1 |
| Buna N | —0.4 | 0.5 |
| Buna S | 0.9 | 5.5 |
| Butyl | 1.3 | 2.3 |
| "Hypalon" 40 synthetic rubber | 0.3 | 2.0 |
| Natural rubber | 3.7 | 13.0 |
| Neoprene W | —0.1 | —0.2 |
| "Nordel" hydrocarbon rubber | 1.5 | 6.1 |
| Silicone | 20.0 | 15.0 |
| "Thiokol" FA polysulfide | —0.7 | 1.2 |
| "Viton" A fluoroelastomer | 0.4 | 0.8 |

*Linear swell can vary with changes in compounding and curing of the elastomer.

### Coatings

There was no effect on the following magnet wire coatings when exposed to "Freon" T-WD 602 and "Freon" TF in normal cleaning operations (immersion in liquid for five minutes at 75°F). Most coatings are also unaffected by higher temperatures and longer contact with the solvent.

"Acrylex" acrylic
"Alkanex" terephthalate polyester
"Anavar" isocyanate-modified polyvinyl formal
Enamel "G" polyurethane
"Ensolex"/ESX solderable acrylic
Epoxy
"Formvar" polyvinyl formal
"Nyclad" nylon-coated polyvinyl formal
Oleoresinous enamel
"Pyre-ML" polyimide

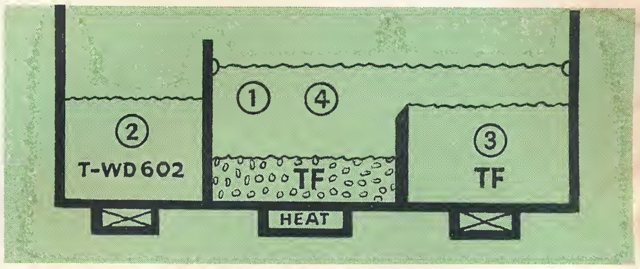
### Metals

"Freon" T-WD 602 solvent is compatible with most metals in normal cleaning cycles. No problem should be encountered with short cleaning exposures to the following metals: steel, nickel, "Monel", copper, aluminum and magnesium. Prolonged exposures may require special precautions. Zinc and zinc alloys are particularly reactive and, in time, will become attacked and cause noticeable solvent decomposition. For this reason, galvanized equipment should not be used in the cleaning system. Extended exposure to aluminum and magnesium, particularly if freshly machined surfaces are present, also may cause some solvent degradation. Ferrous metals may rust from long contact with the water phase.

## CLEANING PROCESS

The "Freon" TF solvent portion of T-WD 602 is an excellent solvent for oil soluble soils and the water portion can dissolve water soluble salts and other inorganic matter. An ideal cleaning system consists of the following steps:

1. For heavily soiled or greasy parts, first rinse in "Freon" TF solvent vapor.
2. Immerse in an ultrasonically-agitated bath of "Freon" T-WD 602 solvent for 30 seconds to 3 minutes.
3. Immerse in an ultrasonic bath of "Freon" TF solvent to remove residual surfactant.
4. Rinse in pure "Freon" TF solvent vapor.




"Freon" T-WD 602 should not be boiled and cannot be used for vapor degreasing.

## BATH RENEWAL

"Freon" T-WD 602 solvent is a water-in-oil type emulsion with unique properties that result in an unusually long cleaning life for greater cleaning economy. When water-soluble salts such as sodium chloride are removed by "Freon" T-WD 602, they combine with the water which then separates to form a separate layer. Removal of this layer disposes of electrolytes and many other water-soluble contaminants. If clean water then is added back into the "Freon" T-WD 602, the original cleaning powers can be restored. Bath renewal is part of the cleaning process and should be done periodically (for example, daily) depending upon the rate of contamination buildup. The method for bath renewal is as follows:

1. Allow the bath to stand without agitation until the soils come to the top in the water layer. Overnight settling is a convenient practice.

2. Skim off this layer and place it in a graduated cylinder or measuring cup to measure the volume. These first two steps can be done simply in a gravity-type cream separator or a hold tank of simple design.

3. Add water equivalent to the volume of the layer removed in step 2 and stir back into solution.

For practical purposes, this renewal process can be repeated indefinitely throughout the life of the bath. Bath life is limited by the buildup of oil-soluble contaminants which are not removed by this process and, consequently, stay in solution after the electrolytes are removed with the water layer. When oil-soluble contamination interferes with cleaning, the bath should be replaced with fresh "Freon" T-WD 602.

## MAKING USE OF SPENT, OIL-CONTAMINATED "FREON" T-WD 602

Reasonably pure "Freon" TF can be recovered by distillation from the spent, oil-contaminated "Freon" T-WD 602 solvent mentioned in the previous paragraph. Many vapor degreasers can be used for this purpose by boiling the contaminated solvent and collecting the condensate in the ultrasonic, clean solvent tank.

During the distillation process, water may accumulate as a layer on top of the distillate. If water is not eliminated automatically by a built-in separator, it should be removed by other means such as by decanting or separation in a gravity-type cream separator. The distillation residue should be discarded.

Excessive temperature should be avoided during distillation to prevent ignition of oils in the still residue. Recovered "Freon" TF solvent can be used for fresh bath makeup in the "Freon" TF ultrasonic vapor degreaser.

## AMMONIATED "FREON" T-WD 602

The addition of ammonium hydroxide (or ammonia) to "Freon" T-WD 602 solvent gives it metal brightening properties and increases cleaning effectiveness. This formulation is made by adding commercial ammonium hydroxide (27–30%) directly to the "Freon" T-WD 602 solvent.

| Amount of "Freon" T-WD 602 to be ammoniated | Amount of Ammonium Hydroxide to add | | |
|---|---|---|---|
| | lbs. | fl. ozs. | mls. |
| 660 pounds (55-gal. drum) | 1.2 | 20.3 | 600 |
| 240 pounds (20-gal. drum) | .44 | 7.4 | 220 |
| 60 pounds (5-gal. pail) | .11 | 1.9 | 55 |
| 12.5 pounds (per gallon rate) | .022 | 0.4 | 11 |

The ammonia content of the cleaning solution is depleted by ultrasonic degasification, acidic soils, and removal with the contaminated water layer. Therefore, addition of 158 ml (5.3 fluid ounces) of commercial ammonia (27–30%) per gallon of fresh water used for bath renewal is recommended. Distillation recovery of "Freon" TF solvent from a used "Freon" T-WD 602 ammoniated bath normally requires extra ventilation to prevent accumulation of released ammonia fumes which have a threshold limit value (TLV) of 50 ppm.

## SAFETY

"Freon" T-WD 602 is neither flammable nor explosive. The liquid solvent is relatively nontoxic and the threshold limit value of the solvent vapor is estimated to be about the same as for "Freon" TF solvent . . . 1000 ppm. However, the solvent vapors can be decomposed by open flames or hot surfaces, such as those in space heaters, to form decomposition products that are toxic and corrosive.

## SPECIFICATIONS

Appearance—clear, pale yellow emulsion

Composition (by weight %)

| | |
|---|---|
| "Freon" TF | 91.5 ± 0.4 |
| Water | 6.0 ± 0.2 |
| Surfactant | 2.5 ± 0.2 |

## PACKAGING AND AVAILABILITY

"Freon" T-WD 602 is available in 5-, 20- and 55-gallon drums, in tank truck and tank car quantities. Prompt delivery is assured by the many Du Pont plants and warehouses located throughout the country.

## SALES REPRESENTATIVES

"Freon" T-WD 602 is sold through sales representatives of selected cleaning equipment manufacturers who are authorized sales agents for Du Pont.

These agents are uniquely qualified to recommend, engineer, design, and install a complete cleaning system (solvent and equipment) to handle your cleaning problem. Both Du Pont and its authorized agents maintain laboratory facilities and provide technical services to assure an optimum solution and continuing service for your specific cleaning programs.

For further information on "Freon" solvents or equipment for "Freon" solvents, contact one of the following Du Pont "Freon" Products Division District Offices:

E. I. du Pont de Nemours & Co. (Inc.)
"Freon" Products Division
60 Glenwood Avenue
East Orange, New Jersey 07017
Telephone: Area Code 201
676-1112

E. I. du Pont de Nemours & Co. (Inc.)
"Freon" Products Division
7 South Dearborn Street
Chicago, Illinois 60603
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222-5000

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Palo Alto, California 94304
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326-2840

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"Freon" Products Division
324 Gulf Bldg., 712 Main Street
Houston, Texas 77002
Telephone: Area Code 713
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______________________

______________________

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Technical Bulletin

# FREON®

Cleaning Agents

# "FREON" TF Solvent

## SUMMARY

"Freon" TF solvent exhibits a selective solvent action which permits its use in the removal of oil, grease, and dirt from objects without harm to metal, plastic, or elastomeric parts.

In addition to this unusual cleaning property, "Freon" TF exhibits a washing and penetrating action which adds to its effectiveness as a cleaning agent. When agitation or solvent flow is used in the cleaning operation, metal surfaces are often thoroughly cleaned even though the gums and oxidized materials present may not be completely dissolved by the solvent. This action is due to the high density and low surface tension of "Freon" TF which enables it to wet the surface of most materials and wash away dirt and sludge.

"Freon" TF is particularly suitable and useful in ultrasonic and vapor degreasing equipment. Soils which are normally insoluble in any solvent can often be removed by "Freon" TF with cavitation in ultrasonic units.

Objects can be vapor rinsed much more quickly in a "Freon" vapor degreaser without the necessity of exposing them to the relatively high temperatures heretofore required.

"Freon" TF is nonflammable, nonexplosive, virtually nontoxic, exceptionally pure, and stable in use.

## INTRODUCTION

"Freon" TF solvent is one member of the family of fluorocarbon chemicals developed by Du Pont and marketed under the well-known trademark "Freon".

"Freon" compounds have been in use for many years. Originally developed as refrigerants, they are now w[illegible] as aerosol propellents, solvents and cleaning ag[illegible]inguishing agents, dielectric fluids, coolants a[illegible] liquids. These widely divergent uses have been possible because all "Freon" compounds are:

• Nonflammable • Virtually nontoxic • Chemically and physically pure • Chemically and thermally inert • Stable

One of the distinguishing characteristics of the "Freon" compounds is that, as a group, their freezing and boiling points cover a very wide range. For example, tetrafluoromethane freezes at −299°F and boils at −198.4°F while, at the other end of the scale, tetrachlorodifluoroethane freezes at +79°F and boils at +199°F. One or more of the "Freon" compounds, therefore, is a liquid from −299°F to +199°F, a 500°F temperature range.

In practical cleaning operations, of course, a solvent must be a liquid at normal ambient temperatures. Moreover, it is desirable that the solvent not have an excessively high boiling point so that,

1. Parts can be processed through a vapor rinsing process quickly and efficiently without the excessive residence time required to reach the high boiling point of chlorinated solvents.

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2. Parts can be cleaned in vapor rinsing processes without raising their temperature to the point where temperature sensitive elements or materials are affected.

3. Parts can emerge from vapor rinsing cool enough to handle immediately for further processing.

4. In critical cleaning applications, the solvent evaporates rapidly and minimizes the time during which the liquid film can trap air-borne contaminants.

For these and other reasons discussed in this bulletin, "Freon" TF, which has a boiling point of +117.6°F, meets most of the requirements of an ideal solvent—especially because it also has the inherent desirable physical, chemical, and safety properties common to the "Freon" family.

"Freon" TF is a pure chemical (trichlorotrifluoroethane) and is used as such in solvent cleaning applications. In many cases soils are a complex mixture of organic and inorganic contaminants and cannot be removed by solvent action alone. Since the chemistry of soils varies, in many cases, the chemistry of the cleaning agent must be similarly adjusted to remove them. For this reason, "Freon" TF is also used as the base for a variety of "Freon" solvent formulations, all of which inherit desirable properties of their parent and extend the cleaning action of "Freon" cleaning systems to cover a significant range of the spectrum of soils.

This bulletin describes the properties and uses of "Freon" TF in detail. Supplements to this bulletin giving similar information for "Freon" solvent formulations can be obtained from the "Freon" Products District Offices listed or authorized "Freon" solvent sales representatives.

## PHYSICAL PROPERTIES

**TABLE I** — **PHYSICAL PROPERTIES OF "FREON" TF**

| | |
|---|---|
| Chemical Formula | $CCl_2F\text{-}CClF_2$ |
| Molecular Weight | 187.4 |
| Boiling Point at One Atmosphere, °F | 117.6 |
| °C | 47.6 |
| Freezing Point, °F | −31.0 |
| °C | −35.0 |
| Critical Temperature, °F | 417.4 |
| °C | 214.1 |
| Critical Pressure, psia | 495.0 |
| atm | 33.7 |
| Density at 77°F (25°C) | |
| Liquid, lbs/gal. | 13.06 |
| lbs/ft³ | 97.69 |
| grams/cm³ | 1.565 |
| Sat'd Vapor at boiling point, lbs/ft³ | 0.4619 |
| grams/liter | 7.399 |
| Latent Heat of Vaporization at b.p., Btu/lb | 63.12 |
| cal/gram | 35.07 |
| Specific Heat at 70°F (21.1°C), Btu/(lb) (°F) or cal/gram (°C) | |
| Liquid | 0.213 |
| Sat'd Vapor (Cp) | 0.152 |
| Thermal Conductivity at 70°F (21.1°C), Btu/(hr) (ft²) (°F/ft) | |
| Liquid | 0.043 |
| Sat'd Vapor | 0.00430 |
| Viscosity at 70°F (21.1°C), Centipoises | |
| Liquid | 0.694 |
| Sat'd Vapor | 0.0102 |
| Refractive Index of Liquid at 79.7°F (26.5°C) | 1.355 |
| Surface Tension at 77°F (25°C), dynes/cm | 19.0 |
| * Relative Dielectric Strength (nitrogen = 1) | 3.9 |
| Dielectric Constant | |
| Liquid at 86°F (30°C) | 2.44 |
| Sat'd Vapor (0.5 atm) at 79°F (26°C) | 1.010 |
| Solubility of water at 70°F (21.1°C), % by Wt. | 0.009 |
| Solubility in water at saturation pressure & 70°F (21.1°C) % by wt. | 0.017 |
| Diffusivity in air at 77°F (25°C) and 1 atm, cm²/sec | 0.068 |
| ft²/hour | 0.264 |

*At (pressure in mm Hg) (electrode gap in cm) = 50; from a paper by Crowe and Devins presented at the 1955 Conference on Electrical Insulation.

"Freon" TF is a pure, stable, chemical compound. It is a clear, dense, colorless liquid having a faint solvent odor. Table I lists the physical properties which

FIGURE I

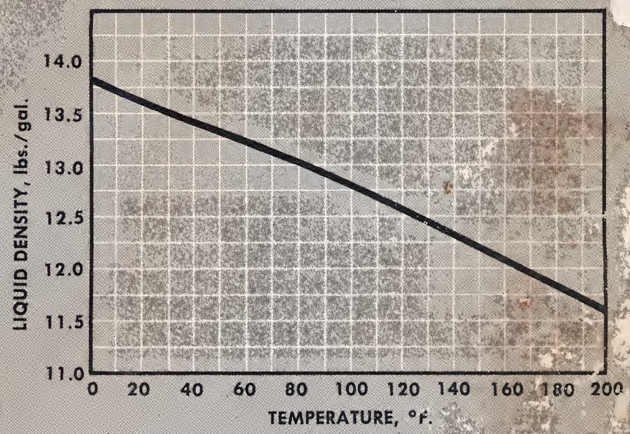
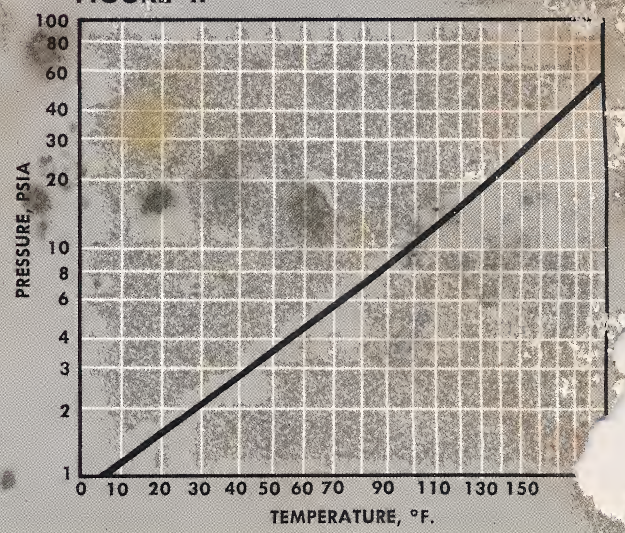



FIGURE II



characterize "Freon" TF. Liquid density and vapor pressure curves of "Freon" TF as a function of temperature are given in Figures I and II.

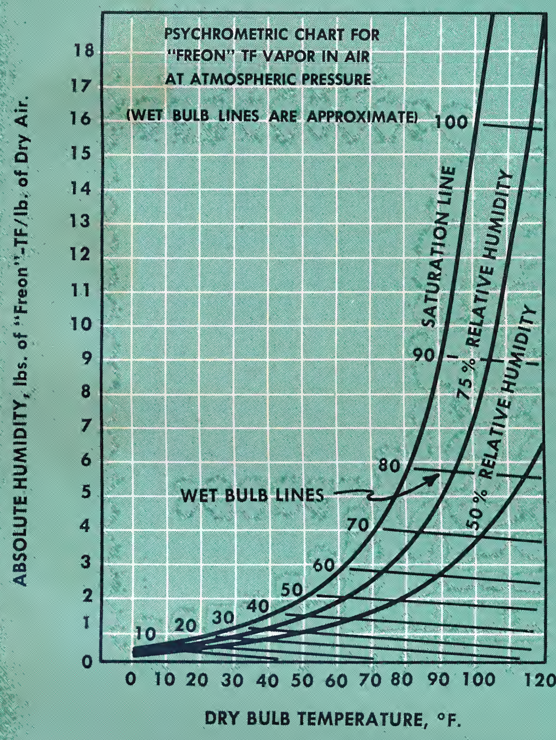
Since "Freon" TF boils at 117.6°F, it is ideal for use in vapor rinsing processes where components of an article to be cleaned might be damaged by higher temperatures. Also, parts emerge from "Freon" TF vapors sufficiently cool and dry, permitting them to be handled immediately for further processing.

The low heat of vaporization means that only a small amount of heat is required to convert "Freon" TF from a liquid to a vapor at the boiling point so that power requirements in a vapor degreaser or for distillation are very low.

"Freon" TF also has a low viscosity which is an important factor in reducing pressure drop in piping equipment, filters, nozzles, etc. High density permits "Freon" TF to suspend insoluble dirt easily and float it away in dipping and spraying operations.

Figure III gives psychrometric curves for "Freon" TF vapors in air. At room temperature, one pound of air is capable of holding four pounds of "Freon" TF vapors. The tremendous appetite of air for "Freon" TF means that drying will take place rapidly at room temperature. In forced air drying systems or ventilation systems, the size and cost of air handling equipment is kept to an absolute minimum.

FIGURE III




## SELECTIVE SOLVENT POWER

An outstanding advantage of "Freon" TF is its ability to clean without damaging any of the materials of construction of the article being cleaned. It is selective in its cleaning action because it will dissolve or flush away the contaminants on the article and yet will not attack metals, plastics, or elastomers.

Table II gives typical guideposts on the compatibility of "Freon" TF with a variety of materials. In general it is completely miscible with petroleum hydrocarbons, chlorinated hydrocarbons, lower aliphatic alcohols, ketones, ethers, esters, animal, vegetable and mineral oils.

Thus "Freon" TF is compatible with most organic systems. When they are present on articles as soil or contaminants, "Freon" TF will remove them leaving a residue-free surface. Most of the materials in the "miscible" column are also cleaning media. "Freon" TF can be substituted for these in most cases or used as a final cleaning step to remove traces of these cleaning media or residues they leave behind.

The solvent power of "Freon" TF is intermediate between aliphatic hydrocarbons and chlorinated hydrocarbon solvents. Since there is no single scale which can rate solvent power on an absolute basis, it is always recommended that specific solvent tests be run for a specific soil. However, a general guide to relative solvent ratings can be obtained by the use of Kauri-Butanol (KB) numbers and solubility parameters. These guides are two independent empirical systems for estimating solvent power and are given in Table III for a number of solvents. In general, the higher the numbers on these solvent scales, the stronger the solvent. In actual practice there are many exceptions to the relative ratings

TABLE II — SOLUBILITY OF VARIOUS SUBSTANCES IN "FREON" TF SOLVENT AT ROOM TEMPERATURE

| Miscible | Very Soluble | Moderately Soluble | Slightly Soluble | Insoluble |
|---|---|---|---|---|
| Acetone | Azobenzene | Acetanilide | Acetamide | Agar |
| Benzene | Benzophenone | Benzil | Anthracene | Casein |
| Carbon Tetrachloride | Camphor | Benzoic Acid | Gum Mastic | Cellulose Acetate |
| Chloroform | Cocoa Butter | Diphenyl | Iodoform | Gelatin |
| Diethyl Ether | Cottonseed Oil | Diphenyl Carbinol | Phenol | Nitrocellulose |
| Ethanol | Naphthalene | Ester Gum | Salicylic Acid | Shellac |
| Hexane | Thymol | Hexachloroethane | Tartaric Acid | Starch |
| Kerosene | Tribromophenol | Phthalic Anhydride | Urea | Sugar |
| Methyl Alcohol | Silicone Oils | Stearic Acid | Paraffin Wax (MP 141°F) | Water |
| Mineral Oil | | Paraffin Wax (MP 126°F) | | Glycerol & Most Polyhydric Alcohols |
| Ethyl Acetate | | | | |

suggested by these guides. Solvent power is only one of a number of physical and chemical factors involved in the selection of a cleaning agent. It should be used only for the purpose of the crudest possible screening of candidate cleaning materials.

**TABLE III** GUIDES TO RELATIVE SOLVENT POWER

| Solvent | Kauri-Butanol Number | Solubility Parameter |
|---|---|---|
| Kerosene | 29 | 7.2 |
| "Freon" TF | 31 | 7.2 |
| n-Heptane | 35 | 7.4 |
| Stoddard Solvent | 37-39 | 7.4-7.5 |
| Benzene | 105 | 9.2 |
| Methyl Chloroform | 120 | — |
| Trichloroethylene | 130 | 9.3 |
| Methylene Chloride | 136 | 9.7 |
| Chloroform | 208 | 9.3 |

## EFFECT ON MATERIALS OF CONSTRUCTION

A clear-cut distinction must be made in the following two ways when using the term "materials of construction" in cleaning applications:

1. The materials used in construction of the cleaning equipment which involves continuous exposure to the solvent under a variety of conditions.
2. The materials used in construction of the article being cleaned which is exposed for relatively brief time intervals to the cleaning agent under a specific set of conditions.

With few exceptions "Freon" TF can be used in equipment involving common, inexpensive materials of construction. With almost no exceptions "Freon" TF can be used to clean articles made of any material of construction.

The ability of "Freon" TF to remove soils without damage to complex fabricated articles has led to important savings by permitting assembled units to be cleaned rather than cleaning separate parts in separate systems prior to assembly. Similarly, in maintenance cleaning, many articles need not be disassembled, thus saving the labor of disassembly or permitting articles to be salvaged which might otherwise have to be discarded because cleaning was considered too costly.

### *Metals*

"Freon" TF can be used to clean metals under normal cleaning conditions either as liquid in cold cleaning or in vapor rinsing processes. As with all solvents, when blended with other solvents or contaminated by water or other liquids the compatibility of "Freon" TF with metals may be altered. The selection of materials of construction for the cleaning equipment used, therefore, must recognize the over-all compatibility of the solvent after contamination with soils. For example, the compatibility of pure "Freon" TF with various metals in laboratory tests is given in Table IV. Test pieces of metal were sealed in glass tubes containing "Freon" TF in air and stored for 100 hours at 117.6°F (the boiling point at atmospheric pressure).

Table IV shows that nearly any metal is suitable with pure "Freon" TF. However, the presence of excessive water will cause attack on more reactive metals such as zinc, aluminum, and magnesium. In such cases where excess moisture cannot be controlled by use of a water separator or a drying medium, it is recommended that more resistant metals such as stainless steel, copper, brass, Inconel, nickel, etc. be used for construction of cleaning equipment. Plastic linings such as phenolic resin can guard against moisture attack on steel and are suitable with "Freon" TF because of its low boiling point and compatibility with plastics.

**TABLE IV** COMPATIBILITY OF "FREON" TF WITH METALS

| Metal | Sealed Tube Tests 100 Hours 117.6°F Corrosion Rate Inches/Month* | Corrosion Appearance |
|---|---|---|
| 1020 Steel | Nil | None |
| 304 Stainless Steel | Nil | None |
| Nickel | Nil | None |
| Monel | Nil | None |
| Copper | $12 \times 10^{-6}$ | Slight tarnish |
| Aluminum | Nil | None |
| Zinc | $6 \times 10^{-6}$ | None |
| Magnesium | $21 \times 10^{-6}$ | Slight corrosion |
| Tin** | Nil | None |

*Nil means corrosion rate was below limit of weighing accuracy or less than $6 \times 10^{-6}$ inches/month.
**91 days at 194°F.

Continuous exposure of the reactive metals to "Freon" TF/water and "Freon" TF/alcohol blends is not recommended. For this reason prolonged contact of such mixtures with zinc, aluminum, magnesium, beryllium, etc. should be avoided. However, these same reactive metals can be and are cleaned in "Freon" TF since cleaning times are measured in terms of seconds or minutes (especially in ultrasonic systems).

### *Elastomers*

The effect of solvents on an elastomer depends on the nature of the polymer, the compounding formulation used, the curing or vulcanizing condition, the presence of plasticizers or extenders, and other elastomer variables. For these reasons, it is difficult to make generalizations on the effects of any solvents on elastomers so it is always best to conduct tests which are specific to the application involved. Such tests have been run in which the effects of both brief and prolonged exposure of elastomers to various solvents have been measured. These tests show that "Freon" TF almost always has substantially less tendency to swell elastomers, less tendency to extract the plasticizers which are necessary to maintain elastomer properties, and almost never does permanent damage to an elastomer even after prolonged immersion.

**TABLE V**

**PERCENT MAXIMUM LINEAR SWELL OF ELASTOMERS**
Immersion in Solvents at 75°F and 130°F

| Elastomer | "Freon" TF 75°F | "Freon" TF 130°F | Stoddard Solvent 75°F | Stoddard Solvent 130°F | Carbon Tetrachloride 75°F | Carbon Tetrachloride 130°F | Methylene Chloride 75°F | Methylene Chloride 130°F | Methyl Chloroform 75°F | Methyl Chloroform 130°F | Trichloro-ethylene 75°F | Trichloro-ethylene 130°F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Neoprene W polychlorobutadiene | 1 | 3 | 10 | 11 | 35 | 43 | 43 | 38 | 35 | 49 | 43 | 46 |
| Buna N Butadiene/acrylonitrile | 1 | 1 | 1 | 1 | 11 | 11 | 52 | 65 | 24 | 33 | 26 | 36 |
| Buna S (SBR) Butadiene/styrene | 9 | 9 | 28 | D | 31 | D | 26 | D | 44 | D | 65 | D |
| Silicone polysiloxane | 34 | 36 | 29 | 26 | 35 | 36 | 27 | 31 | 33 | 37 | 49 | 35 |
| Butyl Isobutylene/isoprene | 21 | 23 | 37 | 60 | 56 | 60 | 19 | 26 | 35 | 41 | 42 | 67 |
| Natural Rubber | 17 | 19 | 50 | 29 | 44 | 42 | 34 | 60 | 59 | 58 | 67 | 41 |
| "Thiokol" FA organic polysulfide | 1 | 1 | 1 | 1 | 14 | 9 | 59 | D | 12 | 11 | 27 | 48 |
| "Hypalon" 40 chloro-sulfonated polyethylene | 1 | 5 | 12 | 17 | 33 | 40 | 39 | 39 | 34 | 46 | 36 | 51 |
| "Viton" A hexafluoro-propylene/vinylidene fluoride | 5 | 6 | 1 | 1 | 1 | 3 | 8 | 10 | 4 | 9 | 3 | 4 |

D—Disintegrated.
"Hypalon" and "Viton" are registered trademarks of E. I. du Pont de Nemours & Co.
"Thiokol" is a registered trademark.

The effect of various solvents on elastomers is given in Table V. In these tests, ¼" x 2" strips were immersed in 4 cc of the solvent until maximum swelling was observed. The data represent the percent linear swell after immersion at 75°F and 130°F. These data show that when "Freon" TF is used, there is a much wider latitude of choice of elastomers. As materials of construction, neoprene, Buna N, "Thiokol" polysulfides, "Hypalon" and "Viton" can be used.

With regard to the use of elastomers when they are integral parts of articles to be cleaned, further tests were conducted in which progressive swelling in the presence of "Freon" TF was measured at various exposure times. In addition, permanent effects such as per-

**TABLE VI**

**EFFECT OF "FREON" TF ON ELASTOMERS**

| Elastomer | TEST B: % linear swell during immersion at room temperature for hours shown: 1/12 | 1 | 4 | 168 | TEST B: % permanent effects after 168 hours of immersion: Permanent Swell* | Extraction** | TEST A: % maximum linear swell regardless of immersion time required: 75°F | 130°F |
|---|---|---|---|---|---|---|---|---|
| Neoprene W | — | 0 | 1 | 2 | −4 | −8 | 1 | 3 |
| Buna N | — | 0 | 0 | 1 | 0 | — | 1 | 1 |
| Buna S | 1 | 2 | 8 | 13 | −2 | −8 | 9 | 9 |
| Silicone | 6 | 13 | [illegible] | 33 | −1 | −2 | 34 | 36 |
| Butyl | — | 1 | 4 | 16 | 0 | 4 | 21 | 23 |
| Natural Rubber | 2 | 9 | 21 | 31 | −1 | −4 | 17 | 19 |
| "Thiokol" FA | — | 0 | 0 | 0 | 0 | −1 | 1 | 1 |
| "Hypalon" 40 | — | 0 | 1 | 2 | −2 | −2 | 1 | 5 |
| "Viton" A | — | 0 | 0 | 2 | 1 | 0 | 5 | 6 |
| "Adiprene" L | — | 0 | 1 | 4 | 1 | −1 | — | — |
| "Nordel" | — | 4 | 11 | 12 | 4 | −9 | — | — |
| "Adiprene" C | — | 1 | 2 | 7 | 1 | −3 | — | — |

*Negative result indicates shrinkage.
**Negative result indicates loss in weight
—Indicates no test run.

"Hypalon", "Viton", "Adiprene", and "Nordel" are registered trademarks of E. I. du Pont de Nemours & Co.
"Thiokol" is a registered trademark.

manent change in dimensions of the elastomer and extraction of ingredients from the elastomer were measured. These data are given in Table VI under Test B. The data listed under Test A are the immersion swelling data for "Freon" TF repeated from Table V. Note that in the case of Buna S and Natural Rubber, Test A results of maximum swell are lower than the results in Test B. This is a good illustration of the test-to-test reproducibility on different samples of apparently the same elastomer. It underscores the suggestion to run specific tests for any given application.

The principle conclusion to be drawn from Table VI—Test B, however, is that even for the elastomers which show significant immersion swelling in "Freon" TF, the permanent effects are generally so low as to be negligible. This is especially true considering that the permanent effects were measured after 168 hours immersion. Had these effects been measured after the 5 minute immersion, it is safe to predict that they would have been immeasurable in all cases. These data substantiate the conclusion that for the exposure times involved in cleaning applications "Freon" TF will not damage elastomers.

## Plastics

The effect of solvents on plastics is somewhat analogous to their effect on elastomers. Results of direct immersion tests conducted at various temperatures and exposure times are given in Table VII.

In these particular tests, visual observations were made of the condition of the plastic at the end of the test and the results recorded on an empirical scale from 0-6; i.e. from no effect to complete disintegration. Effects ranged from "Delrin", on which no solvent caused attack to polystyrene, which was seriously attacked by all solvents except in the 4 hour room temperature test with "Freon" TF where no effect was observed. No other solvent matched the compatibility of "Freon" TF with these plastics under any test conditions.

Based on these results, it is apparent that "Freon" TF can be employed in cleaning plastics or articles including plastic parts almost without exception. The lack of effect even at high temperatures also means that for the first time such items can be processed in vapor rinsing equipment.

## Coatings

**Electrical Insulation:** Most insulation wire coatings and other electrical insulating materials are not adversely affected by "Freon" TF. In one series of tests, various wire insulations were stored in sealed-tubes in the presence of different solvents for 100 hours at 130°F. The samples were visually inspected and the coating lightly scraped to determine its hardness. The results are shown in Table VIII. A numerical key is used to facilitate comparisons.

No solvent other than "Freon" TF is completely safe with all these wire coatings. Motors, potentiometers, relays and all electrical components using such wire enamel coatings can be cleaned using "Freon" TF with complete confidence.

**Paper Insulation:** Paper slot-liner insulation used in many electrical devices is not appreciably affected by "Freon" solvents. Rag paper was exposed to "Freon" TF vapors for 192 hours. Anhydrous "Freon" TF and samples saturated with water were used in these evaluations. In all cases there was no loss of tensile strength or tendering of the paper. Further tests with the paper submerged in "Freon" TF at room temperature for 24 hours showed no effect.

**TABLE VII** — **EFFECT OF SOLVENTS ON PLASTICS**

| Plastic | "Freon" TF Solvent A | B | C | Per-chloro-ethylene A | B | C | Tri-chloro-ethylene A | B | C | Methyl Chloro-form A | B | C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| "Delrin" Acetal Resin | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| "Zytel"—101 Nylon | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| "Teflon" TFE Resin | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| "Alathon"—7050 Linear Polyethylene | 0 | 0 | 1 | 1 | 6 | 1 | 1 | 1 | 1 | 0 | 2 | 1 |
| "Alathon" 9140 or 9141 | 0 | 0 | 2 | 0 | 6 | 2 | 1 | 5 | 2 | 0 | 4 | 2 |
| Polyvinyl Chloride (Unplasticized) | 0 | 0 | 1 | 0 | 4 | 4 | 2 | 4 | 4 | 0 | 4 | 4 |
| "Geon"—8700A (High Impact PVC) | — | — | 0 | — | — | — | — | — | 4 | — | — | 4 |
| "Geon"—8750 (Normal Impact PVC) | — | — | 0 | — | — | — | — | — | 5 | — | — | 5 |
| "Kralastic" ABS Polymer | 0 | 0 | 0 | 0 | 4 | 4 | 5 | 6 | 6 | 4 | 5 | 6 |
| Polystyrene | 0 | 3 | 6 | 5 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| "Lexan" Polycarbonate Resin | 0 | 0 | 0 | 2 | 4 | 2 | 4 | 6 | 5 | 5 | 4 | 4 |
| "Lucite" Acrylic Resin (Cast) | 0 | 1 | 0 | 1 | 4 | 4 | 5 | 5 | 6 | 1 | 4 | 6 |
| "Surlyn" A Ionomeric Resin | 0 | 1 | 2 | — | — | — | — | — | — | — | — | — |

**TEST CONDITIONS:** A=4 Hrs at 75°F B=4 Hrs at Solvent boiling point C=100 Hrs at 130°F

**EFFECT KEY:** —=No test run 0=No visible effect 1=Slightly pliable, no significant swelling 2=Slightly swollen and pliable or slightly shrunk and softened 3=Stress cracked and brittle 4=Swollen, curled and rubbery 5=Partially dissolved or disintegrated 6=Totally dissolved or disintegrated

"Delrin", "Zytel", "Teflon", "Alathon", "Lucite" and "Surlyn" are registered trademarks of E. I. du Pont de Nemours & Co. (Inc.). "Geon", "Kralastic", and "Lexan" are registered trademarks.

**TABLE VIII** EFFECT OF SOLVENTS ON MAGNET WIRE COATINGS

Sealed Tube Tests 100 Hours 130°F

| Insulation | "Freon" TF | Stoddard Solvent | Carbon Tetrachloride | Methyl Chloroform | Trichloro-ethylene |
|---|---|---|---|---|---|
| "Formvar" polyvinyl formal | 0 | 0 | 4 | 4 | 3 |
| "Bondar" | 0 | 5 | 1 | 4 | 0 |
| Nylon polyamide | 0 | 1 | 1 | 1 | 1 |
| "Lecton" acrylic | 0 | 0 | 0 | 0 | 0 |
| "Alkanex" | 0 | 0 | 1 | 2 | 3 |
| "Beldol" polyurethane | 0 | 2 | 2 | 1 | 3 |

**EFFECT KEY:** 0—No crazing, coating not softened. 1—Slight crazing, coating not softened. 2—Moderate crazing, coating not softened. 3—Slight crazing, coating softened and easily scraped off. 4—Severe crazing, coating not softened. 5—Severe crazing, coating softened and easily scraped off.

"Lecton" is a registered trademark of E. I. du Pont de Nemours & Co.
"Formvar", "Bondar", "Alkanex", and "Beldol" are registered trademarks.

**Protective Coatings:** Most paint and varnish coatings are not affected by "Freon" TF solvent. Contact with this solvent even for a considerable length of time shows no deleterious results. In specific instances, it is suggested that coated surfaces be tested with the solvent before use.

A typical example of comparative effect of various solvents on surface coatings is shown in Table IX. In this case, machinery enamel was the coating tested.

**TABLE IX** EFFECT OF SOLVENTS ON PAINT

Steel panels with "Dulux"* zinc chromate primer and 2 dip coats of "Dulux" enamel. Stored half in liquid and half in vapor in closed bottles.

| Solvent | Appearance of Test Panel After 196 Hours Exposure at 75°F |
|---|---|
| "Freon" TF | No visible effect |
| Stoddard Solvent | No visible effect |
| Carbon Tetrachloride | Paint softened with slight peeling in liquid phase |
| Methyl Chloroform | Spontaneous peeling in liquid phase |
| Trichloroethylene | Spontaneous peeling in liquid and vapor phases |

*"Dulux" is a registered trademark of E. I. du Pont de Nemours and Co.

## ELECTRICAL PROPERTIES

"Freon" TF has excellent dielectric properties and high resistance to the flow of electric current as shown in Tables X and XI. These properties allow for considerable freedom in cleaning electrical equipment and permit new, more effective cleaning techniques than have been available in the past.

**TABLE X** ELECTRICAL PROPERTIES OF "FREON" TF

| | |
|---|---|
| Dielectric Constant of Liquid at 86°F | 2.44 |
| Relative Dielectric Strength | 3.9 |
| Resistivity, megohm-cm<br>Liquid at 77°F<br>1000 cycles/sec. | >12,000 |

For example, electrical and electronic equipment can be operated while completely immersed in "Freon" TF. The self-cleaning effects of operating rotating electrical equipment or making and breaking contacting devices during immersion assures an effective cleaning job. This self-cleaning method is possible with "Freon" TF only because it will also not attack materials of construction vital to the safe operation of such equipment.

The potential savings in time and labor by cleaning equipment during operation is important in both production and maintenance fields. For one example, in the maintenance of instruments while in service, spray application of "Freon" TF is possible without interrupting the operation involved; the same is true of switches and relays.

**TABLE XI** LIQUID BREAKDOWN VOLTAGE FOR VARIOUS SOLVENTS

Measured at 78°F by ASTM Method D149-55T

| | Kilovolts |
|---|---|
| "Freon" TF | 32 |
| Carbon tetrachloride | 33 |
| Methyl Chloroform | 13 |
| Perchloroethylene | 34 |
| Trichloroethylene | 35 |

## PENETRATION AND WETTING POWER

One valuable property desired in solvents is low surface tension. When studying possible solvents for any application, much attention is usually given to this property. Surface tension receives its importance because it determines to a large degree the relative ability of solvents to wet surfaces, reach into inaccessible areas, and to

penetrate underneath dirt and other contamination. Low surface tension allows the solvent to flow into tiny crevices so that it can exert its solvent cleaning power. It also allows the solvent to penetrate tiny pores of dirt to dissolve binders which will allow the insoluble dirt to be washed away. Thus, with "Freon" TF the tiniest crevices of intricate surfaces are cleansed of particles which are not necessarily completely dissolved by the solvent.

**TABLE XII — SURFACE TENSIONS AT 68°F**

| | Dynes/cm |
|---|---|
| "Freon" TF | 19.6 |
| Petroleum Naphtha | 25.4 |
| Carbon Tetrachloride | 26.8 |
| Stoddard Solvent | 27.6 |
| Methyl Chloroform (at 74°F) | 25.5 |
| Methylene Chloride | 28.2 |
| Benzene | 28.9 |
| Trichloroethylene | 31.6 |
| Water* | 72.8 |
| Water and surface active agents** | 26—38 |

*Chemical Engineers' Handbook, 2nd Edition, 1941.
**"Surface Active Agents", A. M. Schwartz and J. W. Perry, Interscience Publisher 1949.

Among solvents, "Freon" TF is outstanding because of its low surface tension. The good wetting and penetration properties of "Freon" TF indicate its usefulness for effective washing and cleaning action. This penetration power is enhanced by use of mechanical agitators or ultrasonic cleaners. Table XII shows the relative surface tensions of a number of common solvents.

The surface tension of "Freon" TF is so low that it readily wets and spreads out on the surface of "Teflon" whereas other solvents do not. "Teflon" is one example of a material for which "Freon" TF has a unique cleaning action.

## STABILITY

Solvent stability is essential to its dependable performance. If solvents cause a chemical reaction or decompose during use, damage to materials in contact with the solvent becomes widespread and expensive, and solvent recovery and reuse becomes impractical or impossible.

Unlike the chlorinated solvents, "Freon" TF is a pure chemical compound which is inherently stable and, therefore, requires no inhibitors. Exhaustive tests under many conditions have demonstrated this stability in the presence of water, oil, and metals. The useful life of "Freon" TF is thus extended far beyond that of artificially stabilized solvents.

### *"Freon" TF is Stable to Heat*

In one test "Freon" TF was passed through a heated quartz tube at atmospheric pressure. The temperature was slowly raised and the exit gas was tested for decomposition of the product. In this test it was necessary to raise the temperature to 570°F to obtain even the first trace of decomposition.

Of course, the presence of metals adversely influences the thermal stability of solvents. With many solvents, metals usually catalyze solvent decomposition. As an illustration of stability in the presence of metals, "Freon" TF was stored at 300°F for two years with metals as shown in Table XIII. In view of the extended period of storage and the relatively high temperature, the amount of decomposition is almost infinitesimal.

**TABLE XIII — STABILITY OF "FREON" TF IN THE PRESENCE OF METALS**

2 Years Storage at 300°F

| Metal | "Freon" TF Decomposed, % |
|---|---|
| Stainless Steel 316 | 0.4 |
| Iron | 0.3 |
| Copper | 0.3 |

### *"Freon" TF is Stable to Water and Air*

The resistance of "Freon" TF to hydrolysis is greatly superior to chlorinated solvents as shown in Table XIV. In this test, solvents containing iron powder were refluxed in the presence of air through 50 ml of water in an water separator in a modified Soxhlet extractor for 100 hours. At the end of the test, increase in acidity was determined.

**TABLE XIV — HYDROLYSIS OF VARIOUS SOLVENTS**

Solvents refluxed in presence of [illegible] water and iron powder for 100 hours

| Solvent | Increase in Acidity As Equivalent HCl-ppm by weight |
|---|---|
| "Freon" TF | Nil |
| Inhibited trichloroethylene | 9.0 |
| Carbon tetrachloride | 15.6 |
| Inhibited methyl chloroform | 76.7 |

### *"Freon" TF is Stable to Chemicals*

Instances of chemical reactivity of "Freon" [illegible] rare. "Freon" TF is essentially inert to such che[illegible] as nitric acid, liquid oxygen, acetylene, hydr[illegible]bon chlorine, plastics, and elastomers.

Under very selective circumstances, "Freon" TF [illegible] reactive with molten sulfur and amines. Other chemical reactions are also possible, but only in the presence of other materials which act as reaction promoters. For example, "Freon" TF may react with (a) hydrofluoric acid in the presence of certain metallic catalysts, (b)

primary alcohols if free radicals are present, and (c) zinc and beryllium in the presence of alcohols and water.

These chemically reactive systems are either rare or non-existent in cleaning applications. The need for extremely specialized conditions to promote such reactions, however, is illustrated by laboratory tests of beryllium/water/alcohol/"Freon" TF systems as follows:

| | | | |
|---|---|---|---|
| Be + "Freon" TF | Alone | ⟶ | No reaction |
| | +10% alcohol | ⟶ | No reaction |
| | +5% water | ⟶ | No reaction |
| | +water and alcohol | ⟶ | Possible reaction |

For a chemical reaction to occur with Be and "Freon" TF, either alcohol or water must be present in gross amounts. If both are present, less of each is required and although the specific minimum amounts of each have not been established, it is known that both must be present in quantities only possible in completely uncontrolled cleaning systems. That this is so is proved daily by numerous critical cleaning applications in which "Freon" TF is used to clean complex and expensive beryllium parts successfully and without concern.

## *"Freon" TF is Stable Under Degreasing Conditions*

The stability of "Freon" TF was compared to that of some other solvents under simulated vapor rinsing conditions. The solvents were refluxed in the presence of a chlorinated paraffinic oil, a sulfurized lard oil, iron powder, and aluminum turnings, for 24 hours. Table XV shows the results.

**TABLE XV — STABILITY OF SOLVENTS IN VAPOR DEGREASING**

Solvents refluxed in presence of two oils, iron powder, and aluminum turnings for 24 hours

| Solvent | Increase in Acidity Equivalent HCl-ppm by weight |
|---|---|
| "Freon" TF | 4.2* |
| Inhibited trichloroethylene | 52.7 |
| Carbon tetrachloride | 1230.0 |
| Inhibited methyl chloroform | 965.0 |

*This level of acidity as measured by the acidity test is more a measure of the [illegible] content of the dissolved chlorinated cutting oil than the decomposition of "Freon" TF.

## *[illegible] Discussion*

In all of the preceding tests, "Freon" TF was compared to commonly used commercial solvents and in all cases its stability and inertness was very substantially higher. Commercial solvents contain additives to prevent decomposition or chemical attack and in all cases these additives did not provide the protection inherent in pure "Freon" TF.

In addition to the greater margin of safety in cleaning, the stability of "Freon" TF without artificial additives allows it to be recovered and reused for maximum economy. Recovery of the liquid by distillation or of the vapor from air by adsorption or condensation can be accomplished without fear of separating the solvent from its protective additives since none are used. Many users of "Freon" TF recover the material with simple equipment and find the recovered solvent equal in purity and quality to virgin "Freon" TF.

## PURITY

"Freon" TF is one of the purest organic chemicals commercially available. Every lot is analyzed by vapor phase chromatography and must contain not less than 99.8% trichlorotrifluoroethane and not more than 0.2% of other chlorofluorocarbons. It does not contain any deleterious contaminants.

The nonvolatile residue content of "Freon" TF is 2 ppm by weight maximum and usually runs less than 1 ppm. This residue consists of a trace of particulate matter and soluble oil or wax.

This combination of chemical and physical purity is unique among solvents and is insurance against unsatisfactory cleaning performance due to contamination.

## SAFETY

"Freon" TF is nonflammable and virtually nontoxic. The safety of "Freon" TF is substantiated by recognized authorities.

Underwriters' Laboratories Inc. in their report MH-3072 present the results of their studies of the flammability hazard of certain fluorocarbons. As the result of this work, Underwriters' Laboratories Inc. has classified "Freon" TF as "nonflammable" and the product is listed and subject to their re-examination service.

The toxicity of "Freon" TF has been rated, both by Underwriters' Laboratories Inc. and the American Conference of Governmental Industrial Hygienists.

Underwriters' Laboratories Inc. has studied the comparative life hazard of various materials and reported their findings in classifications according to toxicity. Results are given in Table XVI. These data are useful as a guide to acute toxicity hazard where a person might be exposed to gross concentrations of vapors in air for a relatively short period of time.

The ACGIH publishes a guide for safe threshold limits of solvent vapors in air representing concentrations to which it is believed nearly all workers may be repeatedly exposed, day after day, without adverse effect. This guide is useful in assessing the hazard resulting from chronic exposure to relatively low concentrations of solvent vapors. These limits are given on a solvent volume basis (parts of vapor per million parts of air, ppm) and on a weight basis (mg of vapor per cubic meter of air). Representative data for commonly used solvents are given in Table XVII. Carbon dioxide is included; since it is the only material rated above 1,000 ppm because of its presence in normal respiration. On

## TABLE XVI
### UNDERWRITERS' LABORATORIES CLASSIFICATION OF COMPARATIVE LIFE HAZARD OF GASES AND VAPORS

| Group | Definition | Examples |
|---|---|---|
| 1 | Gases or vapors which in concentrations of the order of ½ to 1 percent for durations of exposure of the order of 5 minutes are lethal or produce serious injury. | Sulfur dioxide |
| 2 | Gases or vapors which in concentrations of the order of ½ to 1 percent for durations of exposure of the order of ½ hour are lethal or produce serious injury. | Ammonia |
| 3 | Gases or vapors which in concentrations of the order of 2 to 2½ percent for durations of exposure of the order of 1 hour are lethal or produce serious injury. | Carbon Tetrachloride<br>Chloroform<br>Methyl formate |
| 4 | Gases or vapors which in concentrations of the order of 2 to 2½ percent for durations of exposure of the order of 2 hours are lethal or produce serious injury. | Dichlorethylene<br>Methyl chloride<br>Ethyl Bromide |
| Between 4 & 5 | Appear to classify as somewhat less toxic than Group 4. | Methylene chloride<br>Ethyl chloride |
| | Much less toxic than Group 4 but somewhat more toxic than Group 5. | "Freon" TF |
| 5a | Gases or vapors much less toxic than Group 4 but more toxic than Group 6. | "Freon-11"<br>"Freon-22"<br>Carbon dioxide |
| 5b | Gases or vapors which available data indicate would classify as either Group 5a or Group 6. | Ethane<br>Propane<br>Butane |
| 6 | Gases or vapors which in concentrations up to at least about 20 percent by volume for durations of exposure of the order of 2 hours do not appear to produce injury. | "Freon-12"<br>"Freon-114"[3] |

## TABLE XVII
### 1962 THRESHOLD LIMIT VALUES

American Conference of Governmental Industrial Hygienists

| Substance | Threshold Limit Value Parts Per Million | Threshold Limit Value Milligrams Per Meter³ | Substance | Threshold Limit Value Parts Per Million | Threshold Limit Value Milligrams Per Meter³ |
|---|---|---|---|---|---|
| Carbon Dioxide | 5000 | 9000 | Hexane | 500 | 1800 |
| "Freon" TF | 1000 | 7600 | Perchloroethylene | 100 | 670 |
| Ethyl Alcohol | 1000 | 1900 | Trichloroethylene | 100 | 520 |
| Methyl Chloroform | 500 | 2700 | Chloroform | 50 | 240 |
| Methylene Chloride | 500 | 1750 | Benzene | 25 | 80 |
| | | | Carbon Tetrachloride | 10 | 65 |

this scale of guide to safety, "Freon" TF is rated as an exceptionally safe material.

The preceding information shows that "Freon" TF is unique among commercial solvents because it is both nonflammable and virtually nontoxic. A summary chart comparing these safety properties with other solvents is given in Figure IV.

Although "Freon" TF is much less toxic than many other commercial solvents, it should be used with adequate ventilation and prolonged breathing of vapor should be avoided. "Freon" TF is nonflammable and will not support combustion. However the solvent vapors can be decomposed by open flames or hot surfaces, such as those in space heaters, to form decomposition products that are toxic and corrosive.

In most cases, "Freon" TF can be used without *special* ventilation. Experience has shown that *normal* air movement is sufficient to keep vapors well below the ACGIH threshold limit. In practice, users report that the capital investment in special or larger ventilation systems was avoided by using "Freon" TF in preference to chlorinated solvents.

Another advantage is that "Freon" TF can eliminate the restrictions of designing cleaning operations around ventilating systems. This provides for maximum flexibility of equipment arrangement any time during the life of the cleaning operation.

Under no circumstances should the concentration of any inert gas in air be increased beyond 25 percent by volume. At this point the concentration of oxygen is reduced to a hazardous level.

Since "Freon" TF dissolves natural oils, the hands should be protected with neoprene gloves to prevent drying of the skin or absorption through the skin if prolonged contact is expected. "Freon" TF should not be taken internally.

To illustrate the beneficial effect of "Freon" TF solvent's nonflammable characteristics, a number of flammable solvents were blended with "Freon" TF at

various concentrations. Data in Table XVIII shows the extent to which "Freon" TF elevates the initial flash point of these other solvents. It must be borne in mind, however, that "Freon" TF may have a higher rate of evaporation than the flammable solvents. Consequently, if a significant amount of evaporation occurs, the flammability property of the mixture, as measured by flash points, tends to return to the more hazardous condition. Generally, however, some beneficial elevation of initial flash point is usually retained, at least until more than 50% of the blend has evaporated.

**TABLE XVIII — EFFECT OF "FREON" TF IN SUPPRESSING FLASH POINT OF FLAMMABLE SOLVENTS**

Initial Flash Point, °F (COC*)

| "Freon" TF Blended with | Weight % "Freon" TF in Blend 0 | 10 | 20 | 30 | 40 | 60 |
|---|---|---|---|---|---|---|
| Acetone | 3 | | 36 | | 70 | 104 |
| Ethanol | 55 | 100 | 115 | 120 | | |
| Toluene | 40 | 83 | 103 | | 107 | |
| VM&P Naphtha | 35 | 46 | 57 | 67 | 72 | |
| Stoddard Solvent | 105 | 155 | 178 | no flash | | |
| Mineral Spirits | 130 | 147 | 165 | 182 | | |

*Cleveland Open Cup flash point test.

## CLEANING PROCESSES, EQUIPMENT, AND USES

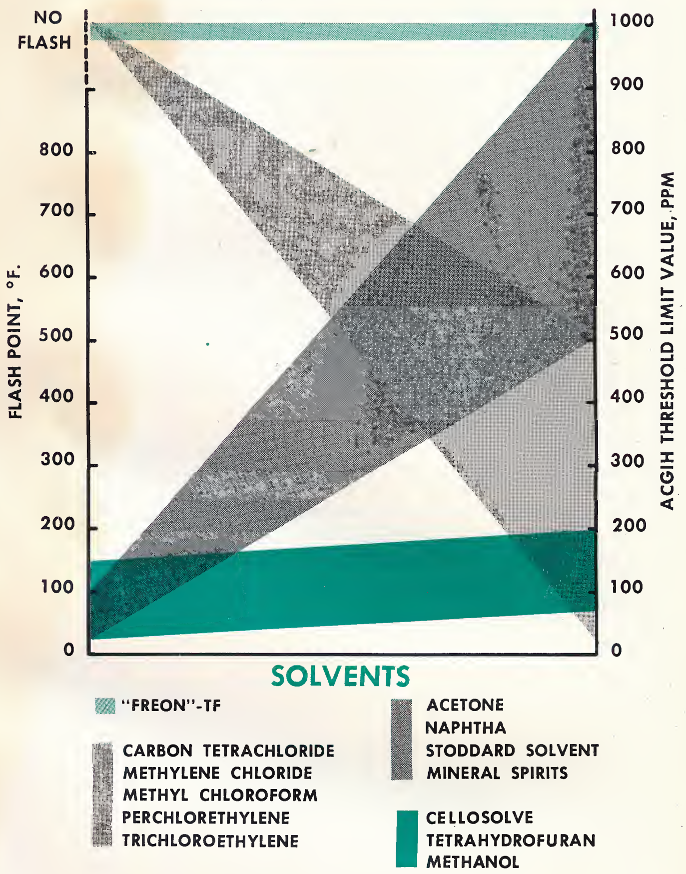
"Freon" TF can be used in all the characteristic methods employed in cold cleaning and vapor degreasing such as:

| *Cold* | *Hot* |
|---|---|
| Wipe | Boiling dip |
| Dip | Vapor rinsing or degreasing |
| Spray | |
| Flush | |
| Brush | |
| Ultrasonics | |

In cold dip processes, the use of "Freon" TF with ultrasonics is in very common use. Frequently "Freon" TF cleaning systems will consist of a combination of cleaning steps with an ultimate pure rinse in "Freon" TF vapors. Several manufacturers of cleaning equipment for "Freon" TF, for example, offer an integrated cleaning unit with an ultrasonic dip and vapor rinse.

For optimum results in terms of cleaning effectiveness and cost, cleaning agents must be used in properly designed systems. Cleaning equipment specifically for use with "Freon" TF is available from a number of manufacturers.

FIGURE IV




In addition to the superior cleaning effectiveness with a pure residue-free cleaning agent such as "Freon" TF, significant economies in over-all cleaning costs also are possible because of its desirable properties. These economies are usually reflected in a lower cost per item cleaned when all fixed and variable cleaning costs are considered. Savings over use of common solvents are possible with "Freon" TF through

1. Recoverability of the solvent for reuse indefinitely.
2. Fewer production rejects.
3. Labor savings (a) in production by substituting one cleaning of an assembly or sub-assembly instead of separate cleaning of separate parts, and (b) in maintenance by eliminating costly disassembly and reassembly of articles with a variety of materials of construction and/or intricate geometry.
4. Reduced investment in safety equipment such as separate or enlarged ventilation systems required with more toxic solvents.
5. Improved employee performance and morale by use of a less hazardous, almost odor-free solvent.

## FOLLOWING IS A PARTIAL LIST OF CLEANING APPLICATIONS INVOLVING "FREON" TF:

| | | | |
|---|---|---|---|
| Gyroscopes | Relays | Bearings | Metal stampings |
| Printed circuits | Potentiometers | Coin chutes | Vacuum tube parts |
| Motors | Photographic film | Missile equipment | Office machines |
| Precision instruments | Magnetic tape | Hearing aids | Hermetic motors |
| Switches | LOX systems | Plastic moldings | Micromodules |

## PACKAGING AND AVAILABILITY

Drum, tank truck or tank car quantities of "Freon" TF are available from four Du Pont plants at Deepwater, New Jersey; Montague, Michigan; East Chicago, Indiana; and Antioch, California. In addition, the "Freon" Products Division maintains 32 warehouses throughout the country.

## SALES REPRESENTATIVES

"Freon" TF is sold through sales representatives of selected cleaning equipment manufacturers who are authorized agents for Du Pont.

These agents are uniquely qualified to recommend, engineer, design, and install a complete cleaning system (solvent and equipment) to handle your cleaning problem. Both Du Pont and its authorized agents maintain laboratory facilities and provide technical services to assure an optimum solution and continuing service for your specific cleaning programs.

For further information on "Freon" solvents or equipment for "Freon" solvents contact one of the following Du Pont "Freon" Products Division District Offices:

60 Glenwood Avenue
East Orange, New Jersey 07018
676-1112
Area code 201

7 South Dearborn Street
Chicago, Illinois 60603
263-7000
Area code 312

701 Welch Road
Palo Alto, California 94304
326-2840
Area code 415



"FREON" PRODUCTS DIVISION
E. I. DU PONT DE NEMOURS & CO. (INC)
WILMINGTON, DELAWARE 19898

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